METEORS: A DELIVERY MECHANISM OF ORGANIC MATTER TO THE EARLY EARTH

PETER JENNISKENS AND MIKE A. WILSON

NASA/Ames Research Center, Mail Stop 239–4, Moffett Field, CA 94035

E-mail: pjenniskens@mail.arc.nasa.gov

DENNIS PACKAN, CHRISTOPHE O. LAUX AND CHARLES H. KRÜGER

High Temperature Gasdynamics Laboratory, Building 520, Mechanical Engineering Department, Stanford University, Stanford, CA 94305–3032

IAIN D. BOYD

Department of Aerospace Engineering, University of Michigan, 3012 Francois-Xavier Bagnoud Building, Ann Arbor, MI 48109–2140.

OLGA P. POPOVA

Institute for Dynamics of Geospheres RAS, Leninsky prospekt 38, bld.6, Moscow 117979, Russia

and

MARK FONDA

NASA/Ames Research Center, Mail Stop 239–4, Moffett Field, CA 94035

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Abstract. All potential exogenous pre-biotic matter arrived to Earth by ways of our atmosphere, where much material was ablated during a luminous phase called "meteors" in rarefied flows of high (up to 270) Mach number. The recent Leonid showers offered a first glimpse into the elusive physical conditions of the ablation process and atmospheric chemistry associated with high-speed meteors. Molecular emissions were detected that trace a meteor's brilliant light to a 4,300 K warm wake rather than to the meteor's head. A new theoretical approach using the direct simulation by Monte Carlo technique identified the source-region and demonstrated that the ablation process is critical in the heating of the meteor's wake. In the head of the meteor, organic carbon appears to survive flash heating and rapid cooling. The temperatures in the wake of the meteor are just right for dissociation of CO and the formation of more complex organic compounds. The resulting materials could account for the bulk of pre-biotic organic carbon on the early Earth at the time of the origin of life.

Instrument Aircraft Campaign (Jenniskens and Butow, 1999). The spectrograph consisted of a 600 l/mm grating, a Nikon f2.8/300 mm lens, and a Pixelvision two-stage thermoelectrically cooled 1024 x 1024 pixel CCD camera. The same spectrograph was used again to probe Perseid meteor spectra from a ground site in August of 1999. Our best spectra probe 1 cm-sized meteoroids with entry velocities of 61 km/s (Perseids) and 72 km/s (Leonids) at altitudes 90–100 km. The spectra cover part of the wavelength range 580–900 nm at a relatively high 0.5 nm resolution (Figures 2 and 3).

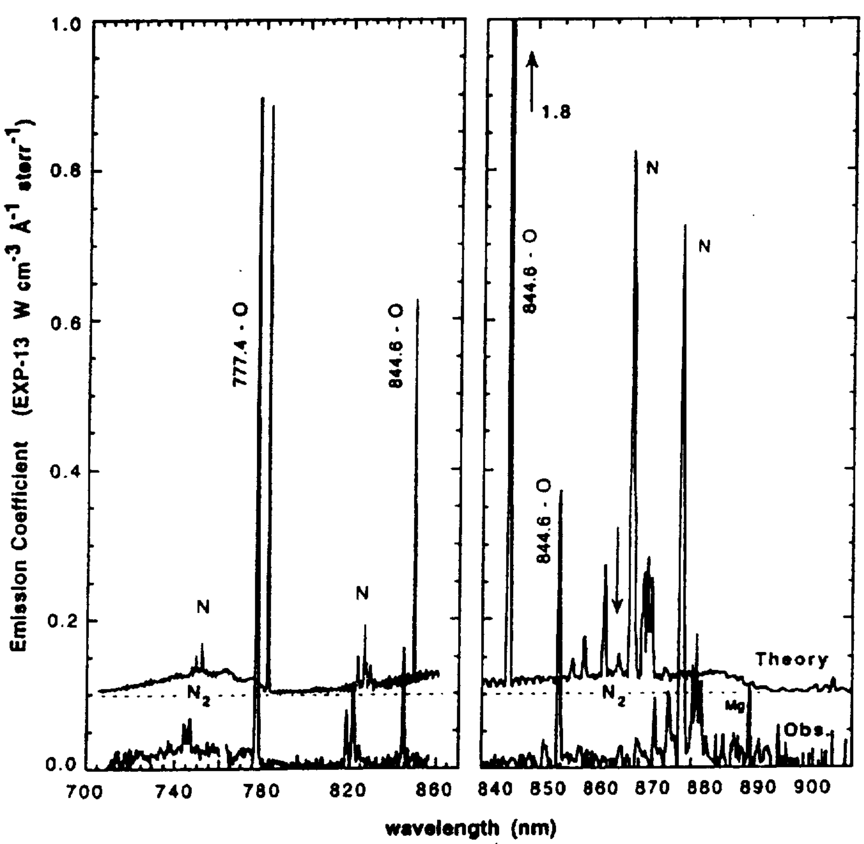

Figure 2. Two Leonid spectra from Nov. 17, 1998, at 17:47:06 UT (left) and 18:08:47 UT (right). The spectra are compared with NEQAIR2 model calculations, which is slightly displaced to facilitate comparison. Note the different line intensities of the OI line emission at 844.6 nm and the NI line emission at 865.6 nm (arrow). The line at 880.7 nm is of MgI.

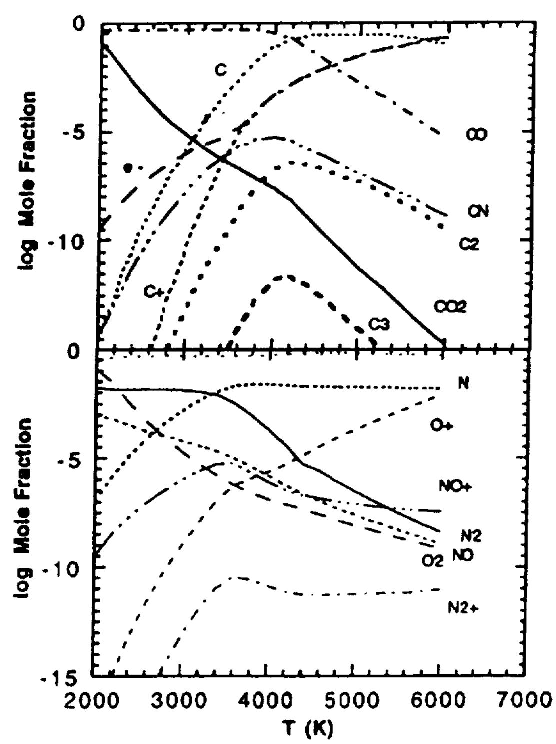

Figure 5. Molecular abundances for equilibrium air plasma at 95 km altitude (P = 10^{-6} atm) in a range of Local Thermodynamic Equilibrium temperatures and for an assumed Mars-like early-Earth atmosphere of particle number composition $O_2/CO_2/N_2/Ar/CO$ = 0.13/95.32/2.7 /1.6/0.08%.

4. The Delivery of Organic Matter to the early Earth.

Interestingly, the study of fast shower meteors can help clarify a role of meteors in creating pre-biotic conditions on Earth, which involved a wide range of meteoroid masses and entry velocities. This is because the wake temperatures of all meteors are in the same narrow range of 3,900 ± 900 K as derived from the well studied meteoric metal atom emission lines (Borovicka and Bocek, 1995; Borovicka and Betlem; 1997; Harvey, 1973). There is no obvious trend with meteor magnitude (mass) or entry velocity. The observed Leonid spectra, too, do not change significantly with altitude or meteor brightness over the observed range.

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